*Please submit this completed application, the supplemental budget spreadsheet, and any relevant supporting documentation by the deadline indicated in your Step 1 notification letter to* *Sustainability-Committee@Illinois.edu**.The Working Group Chairs will be in contact with you regarding any questions about the application. If you have any questions about the application process, please contact the SSC Program Advisor, Micah Kenfield, at* *kenfield@illinois.edu*

# General Information

**Project Name:** Brewing the Best Bankable Biodiesel: A Quality Control Laboratory for the Illinois Biodiesel Initiative (B4)

**Total Amount Requested from SSC:** $29,292.20

**Project Topic Area(s):** [x] Energy [x] Education [x] Food & Waste

 [ ] Land [ ] Water [x] Transportation

# Contact Information

### Project Lead

Applicant Name: Ben McCall

Unit/Department: Chemistry (Professor) and iSEE (Assistant Director for Special Projects)

Email Address: bjmccall@illinois.edu

Phone Number: 217-244-0230

### Financial Contact *(Must be Full-time University of Illinois Staff Member)*

Contact Name: Jenny Kokini

Unit/Department: iSEE (Managing Director)

Email Address: jkokini@illinois.edu

Phone Number: 217-333-5357

Organization Code: 508000

### Facilities Management Contact *(If Applicable)*

Contact Name: not especially applicable, but best contact is Chad Stevens, SCS Director of Facilities & Safety

Email Address: stevens2@illinois.edu

**Primary Project Team**

|  |  |  |
| --- | --- | --- |
| **Name** | **Department** | **Email** |
| Alex Ruzicka | Sophomore, Biochem, Associate Director of Quality Control, Illinois Biodiesel Initiative | aruzic2@illinois.edu |
| Stephen Westman | Sophomore, ChBE, Associate Director of Production, Illinois Biodiesel Initiative | swestma2@illinois.edu |
| Daniel Mace | Junior, ChBE, executive board member of IBI RSO and student in CHEM 199G | dcmace2@illinois.edu |
| Claire Munaretto | M.S. student, AgEcon, President of IBI RSO | munartt2@illinois.edu |

# Project Description

**Please provide a brief background of the project, the goals, and the desired outcomes:**

The Illinois Biodiesel Initiative (IBI) converts waste vegetable oil from campus dining halls into biodiesel (intended for campus vehicles) and biosoap (intended for pre-washing in the dining halls), and aims to do so in a financially and environmentally sustainable manner. IBI began its life several years ago as an RSO, working at the Illinois Sustainable Technology Center, but was evicted from ISTC a few years back. In recent years, IBI has retooled itself under the aegis of iSEE (although with continuing support from and interaction with the RSO), and thanks to SSC “restart” funding it initially set up a small production facility in Roger Adams Laboratory, and has more recently set up a larger (3000 sq ft) facility in Noyes Laboratory. IBI has obtained a 3-year renewable commitment for this space from the Department of Chemistry, and is hoping to also obtain space in the new Integrated Bioprocessing Research Laboratory for larger scale production in 2018 and beyond. The IBI has produced 100 gallons of biodiesel since its move to RAL, and 50 gallons since its move to Noyes, and is aiming to make its first delivery to Garage & Car Pool before the end of the spring semester. At the same time, IBI is working to develop a biosoap formula that will meet Dining Services' needs, and we also hope to make our first delivery this spring. The Initiative is on track to become financially self-sustaining, as outlined in our recent scope change to SSC, with one exception: the costs of testing the biodiesel product to ensure it meets ASTM standards. This proposal is addressed to remedying this obstacle.

The key issue is that our main customer, Garage & Car Pool, understandably requires assurance that the fuel we deliver to them will not cause problems for their vehicles or their underground storage tank. Specifically, they would like assurance that our product meets the ASTM D6751 standard, just like commercially available biodiesel. Having a complete set of the 20 different ASTM tests performed by a commercial lab on each batch is cost-prohibitive (~$1000), so the biodiesel industry has converged on a smaller sets of 9 tests called BQ9000 that are expected to be performed on each batch produced. Commercial BQ9000 testing currently runs $425 per sample. While this is quite reasonable for commercial producers who might run batches of thousands of gallons at a time, our batches are 50 gallons, and each delivery we make to Garage & Car Pool will be ~300 gallons. Even if we only test a sample of each delivery, it would cost us ~$1.40/gallon. Given that our sales price is tied to the market price of petrodiesel (~$2/gallon), and our input costs are ~$1.23/gallon, we would be losing money with every delivery under these circumstances.

The applicant (a Professor of Chemistry) has read all of the ASTM and CEN standards that are part of the BQ9000 suite, and is convinced that trained undergraduate students should be able to conduct these tests up to the standards of commercial labs, given the proper equipment. A list of the tests, the corresponding standards, and the equipment needed is listed in the “additional comments” section at the end of this application. We here request SSC funds to purchase this equipment and set up our own Quality Control Laboratory, which will allow us to do “in-house” BQ9000-equivalent testing of each batch at minimal cost. This will enable us to assure our customers that our biodiesel is up to industry standards, while also allowing us to be financially self-sustaining going forward. Without in-house quality control testing, it will not be possible for the IBI to continue its operations because it would be revenue-negative.

**How will the project improve the sustainability of the Illinois campus and how will the project go above and beyond campus standards?**

The quality control laboratory itself does not directly impact the sustainability of the campus, but it is essential to the continued success of the Illinois Biodiesel Initiative. The IBI will improve the sustainability of the campus by diverting a waste stream (used vegetable oil from the dining halls) and converting it into a substitute for fossil-fuel-based petrodiesel for the campus fleet, as well as upcycling a byproduct into prewash soap for the dining halls. Thus this proposal will have the ultimate effect of reducing our campus waste stream, reducing the greenhouse gas emissions from the campus fleet, and reducing or eliminating the purchase of prewash soap (with its concomitant Scope 3 emissions). Current campus practices are to use petrodiesel (or up to 5% commercially available biodiesel) for the campus fleet and to purchase prewash soap from commercial sources, so the success of IBI will take us far beyond campus standards.

**Where will the project be located? Will special permissions be required to enact the project on this site? If so, please explain and submit any relevant letters of support with the application.**

The quality control laboratory will be located in Room 250 of Noyes Laboratory, which is already being used by IBI for production and testing of biodiesel through an agreement with the Department of Chemistry. IBI has closely coordinated its move into this space with Craig Grant (campus code compliance officer at F&S) and with Chad Stevens (Director of Facilities & Safety for the School of Chemical Sciences). The addition of the quality control equipment does not constitute any additional safety hazards, and no additional permissions are required.

**Other than the project team, who will have a stake in the project? Please list other individuals, groups, or departments affiliated directly or indirectly by the project. This includes any entity providing funding (immediate, future, ongoing, matching, in-kind, etc.) and any entities that will be benefitting from this project. Please attach letters of commitment or support at the end of the application.**

The quality control effort itself does not have any other stakeholders; but the broader Illinois Biodiesel Initiative has many stakeholders, as described in our recent scope change request for the “restart” funding. Primary stakeholders include Dining Services (which provides free waste vegetable oil, and intends to purchase our biosoap once it meets their specifications) and Garage & Car Pool (which intends to purchase our biodiesel once it is demonstrated to meet ASTM standards). We also benefit from cooperation with the Energy Farm (which houses our trailer and will be helping us with fuel deliveries), and the Sustainable Student Farm (which has expressed interest in using our biodiesel in their BCS tractors).

**Please indicate how this project will involve or impact students. What role will students play in the project?**

Students will be directly involved in all aspects of this project, including setting up the instruments, developing detailed “standard operating procedures” for the tests, and actually performing the tests on each batch produced. Students in CHEM 199G are already being trained this semester on the simpler tests (for which we already have, or are fabricating, the needed equipment), and we anticipate that this training will extend to all of the BQ9000 tests in future semesters of the course. The overall Quality Control (QC) effort will be overseen by the applicant, but we anticipate the day-to-day operations will be led by student Alex Ruzicka, who is serving as Associate Director of Quality Control within IBI.

Because of the direct involvement of students in all aspects of the biodiesel production and the QC effort, there is a significant educational component of this project, in addition to the clear environmental benefits of converting a waste stream into a useful fuel that will reduce the campus' greenhouse gas emissions (not to mention an upcycled byproduct in the form of biosoap).

# Financial Information

*In addition to the below questions, please submit the supplemental budget spreadsheet available on the Student Sustainability Committee website. Submission of both documents by the submission deadline is required for consideration of your project.*

**Have you applied for funding from SSC before? If so, for what project?**

I have been actively involved in 4 previous SSC grants:

1) Field to Fuel (granted Spring 2014) – purchase and installation of campus’s first biomass boiler at the Energy Farm, which is now operational!

2) Illini Bike Share (granted Spring 2015) – originally a program to develop an in-house bike sharing system for campus, now transferred to F&S to support the ZipBike initiative

3) Styrecycle (granted Spring 2015) – successful program to purchase a densifier and house it at a community recycling company, together with a student program to collect EPS on campus

4) Illinois Biodiesel Initiative (scope change granted Spring 2016) – “restart” funding to get IBI off the ground again, in its new home with iSEE and the School of Chemical Sciences

**If this project is implemented, will there be any ongoing funding required? What is the strategy for supporting the project in order to cover replacement, operation, or renewal costs?

Please note that SSC provides funding on a case by case basis annually and should not be considered as an ongoing source of funding.**

Once our operations are up and running, we expect to be slightly revenue positive for the production of biodiesel. For each 50 gallon batch of biodiesel, we anticipate the following costs: $2 for transportation of 50 gallons of waste vegetable oil from Ike (no cost for the oil itself), $39.50 for 10 gallons of methanol (when purchased in 55-gallon drums as we now do), $14.75 for 2.35 kg of KOH (when purchased in 20 kg pails), $1.17 for 190 mL of sulfuric acid (when purchased in 2.5 L bottles), and $4 for transportation of the 50 gallons of biodiesel to our trailer at the Energy Farm. This totals $61.42, or $1.23/gallon. We will sell the biodiesel to Garage & Car Pool at a price of at least the wholesale price for petrodiesel, which is highly variable but is presently ~$1.60/gallon. Hence we should be revenue positive for the biodiesel itself, with enough of a margin to take care of various supplies, equipment service, etc. [Note that the key here is not having to pay for testing; hence the current proposal!!] Once we fully develop our biosoap operation, we anticipate additional revenue positivity from that, which we can use to expand our operation in the future. As a result, we are quite confident that we will not need any additional funding from SSC.

**Please include any other sources of funding that have been obtained or applied for. Please attach any relevant letters of support as needed in a separate document.**

SSC is the sole source of financial support for the IBI; the IBI RSO receives separate funding from the Engineering Council and other sources for their club activities, which are not directly related to biodiesel production.

# Environmental, Economic, and Awareness Impacts

*In addition to the below questions, please indicate specific measurable impacts as applicable on the supplemental budget spreadsheet.*

**Which aspects of sustainability does your project address, and how? Does the project fit within any of the iCAP goals? If so, how does the project go beyond the university status quo standards and policies.**

The most direct impact of our project is the reduction in greenhouse gas emissions from the combustion of petrodiesel in the campus fleet; an indirect impact will be the reduction of purchasing of prewash soap from commercial sources, which will reduce the campus’s hard-to-quantify “Scope 3” emissions from purchasing. Our work directly advances Objective 2 of Chapter 4 (Transportation) of the iCAP, which calls on campus to “reduce emissions from the campus fleet by 20%...by FY20,” as well as Objective 3 “to develop scenarios for…conversion of the campus fleet to renewable fuels.” Indeed, biodiesel is specifically called out as a Potential Strategy for this in the iCAP. As the university is not pursuing biodiesel aside from IBI (not counting the standard 5% biodiesel blend in the fuel Garage & Car Pool purchases), our project clearly goes beyond the status quo to advance these iCAP Objectives.

**How will the environmental impacts of your project be measured in the near and long term? What specific monitoring and evaluation processes will you be using to track outcomes and progress?**

The environmental impacts can be estimated simply by tracking the deliveries of biodiesel to Garage & Car Pool, and converting that to a reduction in greenhouse gases. One subtlety is that there are fossil-fuel inputs to the biodiesel production process (mostly in the form of the methanol), and once our operation is fully running we hope to enlist students to perform a Life Cycle Assessment so we can better quantify GHG emission reductions and look for ways to further reduce emissions.

**What is the plan for publicizing the project on campus? In addition to SSC, where will information about this project be reported?**

We are fortunate to be part of iSEE, so our project is publicized by the iSEE communications staff (Tony Mancuso and Olivia Harris). The IBI RSO also engages in various publicity efforts for the initiative, such as tabling at Quad Day, participating in Engineering Open House, etc. Our deliveries to Garage & Car Pool will also be reported in our Campus Carbon Calculator as part of our campus’s greenhouse gas reporting to Second Nature in the context of the Climate Commitment.

**What are your specific, measurable outreach goals? How will these be measured?**

This quality control effort does not intrinsically have outreach goals, as its sole aim is to ensure the viability of the Illinois Biodiesel Initiative. Outreach related to the IBI is primarily conducted by the IBI RSO, through Quad Day and related events.

**Do you have any additional comments or relevant information to aid in evaluation of this application?**

There are 9 specific tests that are part of the BQ9000 protocol; these are briefly described here, along with the equipment needs:

1. Visual appearance. This is a quick check for contaminants, which involves visually comparing a sample of fuel in front of a set of standard black bars on white paper to a set of standard photos, to measure transparency. The standards have already been purchased with CHEM 199G funds, and our most recent batch passed with flying colors! [$0 requested]

2. Acid number. This is a color-changing titration to measure residual free fatty acids in the fuel. We have the necessary equipment on hand; our most recent batch easily passed this test. [$0 requested]

3. Cloud point. In this test, a sample of fuel is placed in a cold bath and gradually cooled down until the fuel becomes cloudy due to the formation of suspended solids; the temperature at which the cloudiness appears is recorded as the cloud point. Using CHEM 199G funds, the School of Chemical Sciences glass shop has just fabricated the necessary apparatus. [$0 requested]

4. Water and sediment. A 100-mL sample of fuel is centrifuged, and the volume (if any) of water and sediment at the bottom of the tube is measured. This requires a special centrifuge that takes very large centrifuge tubes, and we have not been able to locate one on campus. [~$7500 requested for centrifuge, rotor, and special tubes]

5. Flash point. In this test, the temperature at which the vapors above a heated sample of fuel in a closed cup ignite is recorded; this test controls against residual methanol in the fuel. For safety reasons, a special apparatus is needed for this. The only one we have found on campus (in the Asphalt Lab) is an “open cup” tester, and ASTM requires a “closed cup” test. [$4000 requested for Koehler rapid flash point tester; please note that this is the “bargain” option compared to the automated apparatus often used in industry which runs ~$20k]

6. Cold soak filterability test. A sample of fuel is soaked at 40 F for 16 hrs then soaked at 77 F for 2 hrs, then vacuum filtered through a special filter. The length of time needed to filter the entire sample is recorded. This test is designed to control against fuel filters getting plugged at low temperatures. We need two high-precision water baths for the temperature soaks, and a filtration apparatus. [~$3800 requested for the water baths and ~$400 requested for the filtration apparatus]

7. Oxidation stability test. This test evaluates the stability of fuel with respect to being oxidized in storage, by exposing a sample of fuel to a flow of oxygen at elevated temperature and measuring the conductivity of a solution that captures the products of oxidation in the oxygen flow. This pretty much requires a commercial instrument in order to provide reliable test results. The “gold standard” instrument used at Loyola's biodiesel facility costs ~$24k, but we have found a less expensive version that also meets the CEN standard. [~$12,500 requested]

8. Glycerin. This test measures the amount of free glycerin and “total glycerin” (residual mono-, di-, and tri-glycerides) in a sample of fuel using gas chromatography. Fortunately, the Department of Chemistry has an unused gas chromatograph available for us to use (~$12k value!). We only need to purchase an appropriate column and some reagents and standards. [~$1100 requested]

9. Sulfur. EPA requires that diesel fuel have <15 ppm of sulfur to control pollution. We are fortunate to have access to an Inductively Coupled Plasma Optical Emission Spectrometer in the Microanalysis facility in the School of Chemical Sciences, where tests for sulfur can be run for $12.50 per sample. This test will probably not need to be done very frequently, since biodiesel almost always easily passes this test (because vegetable oil intrinsically contains very little sulfur). An initial test performed on our first batch of biodiesel made in Noyes Lab showed that our biodiesel contains less than 8 ppm of sulfur; the ASTM standard requires less than 15 ppm. [$0 requested]